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PROTECTION OF THE ATMOSPHERE: CLIMATE CHANGE

Report on Costing Exercises of measures adopted to limit possible climate changes

Report of the Secretary-General of the Conference

I. INTRODUCTION

1. This paper was prepared by the UNCED Secretariat, to respond to decision 1/11 (c) by the Preparatory Committe, requesting the "... Secretary General of the Conference to draw on, inter alia, the work of competent organs, organizations and bodies of the United Nations system, and other relevant organizations, in initiating appropriate work to estimate the cost, in particular to developing countries, of adopting measures to limit possible climate change and mitigate its adverse effects ... and to report thereon to the Preparatory Committee at its second session". 1/

2. The Secretariat would like to acknowledge the input of members of the Atmosphere Working Party of UNCED as well as other experts in preparing and reviewing this paper. 2/

3. Assessing the costs of CO_2 and other Greenhouse Gas abatement is fundamentally different, and more complex from other assessments, such as those concerning CFCs. While the potentials for GHG reductions are potentially very large, and given these potential energy savings often with negative costs (i.e., with benefits), their assessment is complicated by a number of factors. The scale of the part of the economy producing and using energy is so high that economic incentives implemented to, for example, increase energy efficiency, would have important macro-economic impacts. Since the policies would need to be applied for decades, the costs of fuel and technologies are difficult to predict.

4. These considerations, as well as the general political and economic importance of fossil fuels mean that establishing methodologies and assumptions for assessing abatement costs, and agreeing on a common framework for their analyses, will take a considerable effort both on the research and policy sides.

5. Much of the political debate on the greenhouse effect has focused on the credibility of large-scale climate models that are often used to estimate the effects of a trace gas build up on the composition and behaviour of the earth's atmosphere. Many of these models attempt to evaluate the impact of accumulating carbon dioxide and other gases on the earth's average temperature. Some models also evaluate other impacts, including the effects of global warming on precipitation, soil moisture, and sea level. These computer models have been subjected to intense scrutiny in the last several years, as scientists and policy-makers have tried to shape appropriate responses to the risks of rapid global warming. Major uncertainties, however, still remain.

6. In contrast, considerably less attention has been given to the models and methods used to assess the costs of reducing greenhouse gas emissions and the economic consequences of rapid climate change. This lack of attention is unfortunate, as economic forecasts carry considerable weight in policy deliberations. Recently, increased attention has been applied to the development of improved tools for understanding the costs of rapid climate change and the costs of various response strategies.

7. But even the best economic projections available today are not without major flaws. All suffer substantial limitations. The available economic models tend to emphasize the costs of response strategies while neglecting potential benefits. They ignore the complexity and diversity of the response of the natural environment to global warming. Most models neglect issues of distributional equity among regions as well as the impact on future generations of delaying responses. They often rely on dubious and untested assumptions about market forces and technological innovation. And they fail to explain the successful experiences of those countries, such as Japan, which have voluntarily maintained aggressive and innovative policies.

8. The application of improved tools for evaluating the economic consequences of rapid climate change will be particularly relevant to policy considerations in developing countries for several reasons. First, if no efforts are made to reduce the risks of rapid climate change, the negative impacts of global warming will be felt most strongly in the already-stressed societies of the third world. Second, since most future growth in demand for commercial energy is likely to come in these countries, increasing pressure will be placed on them to limit future emissions of carbon dioxide, both from energy use and from deforestation. Third, since many developing countries are likely to be chronically short of hard currency in the coming decades, anything which can be done to limit the extent of environmental damages and the capital demands of the energy sector will act as a spur for economic development, releasing desperately needed funds for other important purposes.

9. This paper provides a brief survey of recent costing studies and proposes some possible follow-up activities. The first section illustrates alternative definitions of the term "costs" and describes three types of costing studies currently in progress. The second section surveys the recent studies, grouping them by methodological approach and then by subject area. The third section lists some of the key institutions engaged in this area, separating the efforts of international agencies, national governments, NGOs, and others. The fourth section offers some specific suggestions for future activities that could fill some of the remaining gaps in knowledge.

II. DEFINING THE COSTS OF RESPONDING TO CLIMATE CHANGE

10. The term "cost" has been used with a variety of meanings in the recent discussions of the economic consequences of climate change. Some analysts have described the cost of a response strategy as the simple sum of direct investment costs. Using this definition, one could, for example, add up the production costs (or possibly the purchase price) of all the efficient light bulbs installed in residential dwellings plus the trees planted in agricultural areas, plus the new more efficient automobiles that might be purchased if a national commitment was made to limit the emissions of carbon dioxide (CO_2).

11. A more useful definition of the costs of responding to the risks of global warming focuses on the present value of the net investment costs of a particular strategy, relative to some reference strategy or baseline scenario. In this framework, the costs of installing efficient light bulbs, building higher dikes, constructing less energy-intensive industries, changing cropping and driving patterns, and planting trees might be subtracted from the costs of activities that would be pursued in each of these sectors, absent a systematic response to the risk of rapid global climate change.

12. A third, and perhaps more meaningful approach is to define the cost of a general response strategy as the measure of its impact on national, regional, or global GNP. Using this approach, the full social cost of the proposed strategy would be measured in terms of its impact on the estimated regional GNP and compared to the model's estimate of GNP for the relevant area before

implementation of the response strategy. Applying this approach in a complete and systematic manner, however, would require estimating the global economic consequences of climate change, including positive and negative impacts in the agricultural, forestry, and energy sectors, both with and without the proposed strategy - a difficult task for even one country over a multi-decade time horizon.

III. SURVEY OF COSTING STUDIES

13. In general, three types of costing studies have been undertaken in the last few years. These studies pose very different quetions and, not surprisingly, get very different results. The three principal types of studies include (1) assessments of climate impacts, (2) analyses of the costs of adapting to the impacts of global warming, and (3) studies of the costs of reducing greenhouse gas (GHG) emissions.

Climate impacts analyses

14. The first class of studies evaluates the impacts of climate change. These analyses are usually carried out as case studies of particular regions. They typically focus on one type of impact, which may be either a direct or indirect effect of climate change. Such studies may analyse, for example, the effects of sea level rise on a specific deltaic region close to the sea coast or the impacts of climate change on wheat crop production in a traditional agricultural area. Since the future distribution of regional impacts from global warming cannot now be predicted, these studies often assume a canonical view of a warmer world. The classical examples of such studies assume the equilibrium effects of doubling the pre-industrial concentration of carbon dioxide and proceed to estimate the regional economic consequences.

15. The best of such studies use either of two approaches. Some apply simulation models constructed from a hierarchy of biological or physical process models coupled to microeconomic models of typical enterprises and subsequently to regional economic models. Others start with a statistical analysis of historical data to elicit yield or impact relationships. These relationships are then applied to the estimated or assumed conditions derived from the regional climate model to project future yields or impacts.

16. Two types of impact assessment studies have been carried out in recent years, regional studies and national studies. Regional studies have been carried out to assess the effects of future climate change on agriculture, forestry, river basins, and coastal zone management. The most systematic and complete set of climate impacts studies were recently completed by an international team of experts working under the joint sponsorship of the United Nations Environment Programme (UNEP) and the International Institute for Applied Systems Analysis (IIASA). This project, investigated the effects of climate change on world agriculture. The study investigated the effects of doubling the pre-industrial CO_2 concentration on agricultural output from key regions in the United States, USSR, Japan, Finland, and a number of developing countries. Their results indicated that the most vulnerable

regions were likely to include (a) some semi-arid tropical and sub-tropical regions including western Arabia, the Maghreb, western West Africa, the Horn of Africa, and eastern Brazil, and (b) some humid tropical regions in south-east Asia and Central America.

17. Additional studies of climate impacts have been carried out by the governments of the United States, Canada, and Australia. These studies show substantial but not overwhelming damage in various sectors due to global climate change.

Adaptation Studies

18. Studies designed to evaluate the costs of adaptation to future climate change make up the second class of costing studies. Such analyses have also been often carried out as specific regional case studies. They typically concentrate on the effects of a particular class of impacts in a narrowly defined geographical region. Examples of this type of study include assessments of the costs of protecting low-lying coastal areas from salt-water intrusion due to sea-level rise and analyses of the costs of managing commercial forest plantations under changing and uncertain rainfall conditions. The amount of work done in this area has been limited to date. Some important analyses of the situation facing the United States was carried out by the Environmental Protection Agency as part of a Congressionally-mandated study of the impacts of rapid climate change. This study explored, for example, the costs of protecting two coastal United States cities, Charleston, SC and Galveston, TX, against the effects of a one-meter sea-level rise. Another important study was conducted for the Stockholm Environment Institute on the costs of adaptation to sea level rise in the San Francisco Bay. The Netherlands government has also done periodic studies of the costs of protecting that low-lying country against future increases in sea level. Similar studies could be conducted of the costs of protecting such cities as Bangkok, Alexandria, Shanghai, and Venice.

The Costs of Slowing GHG Build-Up

19. The most extensive and voluminous analysis has been done on the third group of studies. These analyses evaluate the costs of reducing the risk of climate change by slowing the build up of greenhouse gases. Such studies typically focus on the relationship between the use of commercial energy, especially fossil fuels, and the release of CO_2. On occasion, other greenhouse gases and other economic sectors (most often agriculture) are considered. Such studies can be broadly characterized into two general classes, based on the type of models employed. These classes are: (1) analyses using "top-down", macro-economic models and (2) analyses using "bottom-up", engineering models. To date, the results of such studies have been inconsistent with each other and generally inconclusive.

20. The "top-down" models typically incorporate representations of historical relationships among various economic sectors and do not provide much detail concerning the effects of new technologies or the impacts of changing behaviour patterns. This class of models often represent such changes through the use of aggregate macro-economic parameters which are difficult to measure precisely from available historical data, under the best of circumstances. These aggregate parameters include the average income elasticity of demand for energy, the elasticity of substitution between fuels, the rate of change in labour productivity, and the rate of autonomous energy efficiency improvement for the total economy or region. Using these parameters and extrapolating existing structural relationships many decades ahead, the "top-down" models tend to yield low estimates of the potential for emissions reductions and high estimates of the potential costs of those reductions.

21. There are four general types of "top-down" models, defined by their underlying structure. The four types include: (1) general equilibrium models that represent the energy sector as one of many dynamic sectors in the economy, all of which evolve over time; (2) partial equilibrium models that represent the energy sector in detail and the rest of the economy as an aggregated "black box"; (3) optimization models that start with a set of assumptions about the costs of various energy-related activities and seek an "optimum" pattern of activity that maximizes some goal or criterion; and (4) resource accounting models that map the physical and economic flows through the economy of a country or region.

22. Some illustrative examples of the "top-down" approach include: (1) the efforts by the United States EPA to develop a dynamic, intertemporal general equilibrium model called GEMINI; (2) a computable general equilibrium model developed at Stanford University that combines a non-linear optimization model and a macro-economic growth model; and (3) a dynamic general equilibrium model of the United States economy developed at Harvard University.

23. Despite the extensive activity in this field, a number of weaknesses and limitations beset these analyses. For example, in addition to the shortcomings noted above, many of the "top-down" macro-economic models often use a single number to represent the energy/GNP elasticity and do not allow this relationship to change over time. This remains common practice despite the historical evidence that this relationship has changed dramatically for most countries in the last 20 years. Furthermore, many such models rely principally on higher energy prices to bring about energy savings even though this requires using very high (and uncertain) estimates of energy price elasticities of demand. More importantly, they ignore the potential for policy-induced innovation. These models often make little provision for non-price induced energy savings measures such as performance standards or information programmes designed to overcome structural failures in energy markets.

24. "Bottom-up" engineering models focus on the characteristics of particular energy technologies. These models reflect detailed studies of the components

of each technology or the processes required to produce a specific product. They assume a rate of change in such key variables as the average energy and materials intensity of production. The total costs or savings due to deployment of the selected technology is treated as the arithmetic sum of the costs or savings estimated for each unit. They ignore the interactions between the technologies under examination and the rest of the economy or region. "Bottom-up" models tend to yield high estimates of the potential for reducing greenhouse gas emissions and low estimates of the total cost.

25. "Bottom-up" models can be divided into two groups. The first group are end-use oriented, cost accounting models in which the analyst identifies the "best" example of technology for a particular end-use and then the various end-uses are accumulated to represent the society as a whole. The second group are a family of optimization models in which the best set of process alternatives is selected from a range of choices to optimize the micro-economics of a particular activity.

26. A number of end-use oriented, "bottom-up" models have recently been developed in the United States and Europe. Some important illustrations include: (1) the work at the Lawrence Berkeley Laboratory that has been extended to 12 developing countries; (2) work at the Battelle Northwest Lab covering the Soviet Union and Eastern Europe; (3) work at the Center for Energy and Environmental Studies that has focused on the United States, Brazil, Sweden, and India; and (4) work at the Stockholm Environment Institute on a number of developing countries, as well as on the United Kingdom and Poland.

27. The "bottom-up" studies are also hindered by important short-comings, but of a different sort from the top-down models. These include lack of consistency in assumptions about fuel prices and discount rates, ambiguous and inconsistent methods for combining the effects of a number of measures or technologies - often ignoring their impact on the larger economy they are embedded within; inconsistent treatment of operations and maintenance costs; and finally a failure to integrate the economics of demand with those of energy supply.

28. Studies of the costs of reducing greenhouse gas emissions have been conducted at the global, regional, and national levels in the last five years. Most of the global studies have used "top-down", macro-economic models and run them out over a period of a century or more. The best-known examples of such studies are the scenarios produced by a joint Dutch-US modelling team for the Intergovernmental Panel on Climate Change, the United States EPA analysis conducted for the Congressional Climate Stabilization Study, the work of Swart and Rotmans for the Netherlands RIVM, the work of Edmonds and Reilly for the United States Department of Energy and the work of Mintzer for the World Resources Institute. A new global model is currently being constructed for the Commission of the European Communities (CEC).

29. A number of regional studies are now planned or underway. Most of these also employ a "top-down" approach. Such studies include an IEA/OECD study using a partial equilibrium economic model of the industrialized countries; and a detailed study of EC countries prepared by the CEC and employing a set of country-specific linear optimization models.

30. The largest number of studies have been done on a national basis. More than 20 such studies were prepared for the Energy and Industry Sub-Group of Working Group III of the IPCC. Most of these studies used top-down, partial equilibrium macro-economic models to project future energy use, CO_2 emissions, and GNP.

31. The Asian Energy Institute in New Delhi is co-ordinating a major study which would develop an extensive data base on variables related to greenhouse gas emissions; evaluate technology and policy options for their abatement; identify specific co-operative projects between countries of the region which would minimize overall emissions; and evaluate economic choices for the countries involved to reduce emissions. The Institute plans to have the results available by the end of 1991.

32. In addition, a number of other country case studies are worth noting. Environment Canada has recently published a study of the potential for achieving CO_2 reductions in Canada based on an analysis using an input-output model of the Canadian economy. A study is now underway for the Enquette Kommission of the German Bundestag to quantify the economic implications of the CO_2 reduction targets set by the German Government. In Norway, the State Pollution Control Authority is assessing the potential reductions achievable and the economic costs of 38 CO_2 eduction options. In India, the Indian Institute of Science in Bangalore has just completed a major study of alternative energy policies to the year 2000 for Karnataka state that includes estimates of potential efficiency improvements, fuel substitution possibilities, and CO_2 emissions reductions compared to the official state plan.

33. The key challenge is to integrate the results of the bottom-up and top-down approaches. This is essential in order to capture the technical specificity of the end-use oriented, engineering approach of the bottom-up work without losing the ability to see the economy of a country or region as a dynamic whole. No consensus now exists on the best method for meeting this challenge.

IV. INSTITUTIONS INVOLVED IN COSTING STUDIES

Regional Organizations

The Commission of the European Communities
The United Nations Economic Commission for Europe
The Association of Southeast Asian Nations

Intergovernmental Agencies

The World Bank
Asian Development Bank
Organisation for Economic Co-operation and Development
International Energy Agency
United Nations Environment Programme

National Governments

United States	Brazil	New Zealand
United Kingdom	China	Australia
France	India	Mexico
Federal Republic of Germany	Bangladesh	
Canada	Indonesia	
Netherlands	Malta	
Italy	Tuvalu	
Denmark	Saudi Arabia	
Sweden	USSR	
Norway	Switzerland	
Japan	Austria	

NGOs

Asian Energy Institute, TERI, New Delhi
Stockholm Environment Institute
Alliance to Save Energy, Washington
Natural Resources Defense Council, United States
Climate Action Network
Lega Par L'ambiente, Italy
Greenpeace
World Wildlife Fund, Washington, DC
Institute for European Environmental Politics
World Resources Institute, Washington, DC
Center for Global Change, Washington, DC
Battelle NW Labs, Washington, DC
Royal Institute for International Affairs, London
Bariloche Institute, Argentina
Africa Center for Technical Studies, Kenya
Bangladesh Institute for Advanced Studies, Dacca, Bangladesh

V. POTENTIAL AREAS FOR ACTION

34. Full advantage needs to be taken of the number of important opportunities which exist to advance the state of the art on the costs of responding to rapid climate change.

35. The most important activity would be to ensure effective coordination of existing studies, and to provide a common framework and data base for the evaluation of existing and future studies. The activity already under way in

UNEP with the co-operation of the Royal Institute for International Affairs in the United Kingdom is relevant. There needs to be good co-operation between this activity, the Secretariat of the Intergovernmental Negotiating Group, and the UNCED Secretariat.

36. In addition to coordination, a number of activities need to be strengthened or accelerated, including:

(a) more complete and thorough review of costing studies and their methodologies;

(b) the preparation of a compendium of impact assessments and adaptation studies, focused specifically on the cost implications of climate change for developing countries if no action is taken. Such an effort would bring together estimates of impacts from sea level rise, agricultural shifts, effects on forestry, and effects of changes in the timing, frequency, severity, and duration of extreme weather events with estimates of the costs of adapting traditional forestry, energy and agricultural practices;

(c) to support ongoing projects and encourage new ones, especially in the developing countries to assess the costs of climate change, such as the one being carried out by the Asian Energy Institute;

(d) a comparison of a "business as usual" scenario with a "no regrets" strategy using one or more of the major modelling tools now available. Such an effort should attempt to bring together a "bottom-up" and "top-down" approach to the overall analysis;

(e) a study to identify the geographic areas and industrial activities of greatest potential vulnerability to rapid climate change. Such a study could provide an alternative to the problems caused by excessive and deceptive aggregation in many previous impact studies which ignore the potential of severe, but localized, impacts.

Notes

1/ Report of the Preparatory Committee for the United Nations Conference on Environment and Development, Official Records of the General Assembly, A/45/46 decision 1/11, paragraph (c).

2/ The paper was based on a technical paper prepared by UNCED by the staff of the Stockholm Environment Institute.

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